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SCRAMBLED VS. ORDERED SEQUENCE IN AUTO-INSTRUCTIONAL PROGRAMS. TEACHING SYSTEMS RESEARCH PROJECT.

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THIRTY-SIX COLLEGE FRESHMEN WERE MATCHED FOR MATH ABILITY AND RANDOMLY ASSIGNED TO AN EXPERIMENTAL AND CONTROL GROUP, TO WORK A 71-ITEM LINEAR PROGRAM IN SCRAMBLED AND ORDERED SEQUENCE, RESPECTIVELY. AN IMMEDIATE POST-TEST SHOWED THAT--ITEM SEQUENCE HAD NO SIGNIFICANT EFFECT ON LEARNING TIME, ERROR SCORE, TEST SCORE, OR TEST TIME. PRIOR MATH ABILITY HAD A SIGNIFICANT EFFECT ON ERROR AND TEST SCORES, BUT DID NOT INTERACT WITH ITEM SEQUENCE. (LH)

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TEACHING SYSTEMS RESEARCH PROJECT

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FOREWORD

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ABSTRACT

An auto-instructional program on elementary probability was presented in scrambled and properly ordered sequence respectively to two groups, each of which numbered 18 freshman psychology students who were classified according to their prior mathematical ability. Students were permitted to proceed once through the linear program at their own pace, and were given a criterion test immediately after completing the learning session. The sequence of items had no significant effect on (a) time required for learning, (b) error score during learning, (c) criterion test score, and (d) time required for criterion test. Prior mathematical ability had a significant effect on error score during learning and on criterion test scores. There was no significant interaction between the type of item sequencing and prior mathematical ability.

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INTRODUCTION

Teaching machines have been characterized by three supposedly important properties:

1. The subject matter is broken down into small, carefully ordered items, allowing the student to respond explicitly to each item.
2. The student is informed immediately after his response to each item whether his response was correct, and thus has a means of immediately correcting a wrong response.
3. The student proceeds on an individual basis in accordance with his own rate of learning.

In an experiment conducted by Roe[3] with college freshman engineering students, it was found that if a carefully ordered sequence of learning items was prepared, students learned equally well whether they were required to compose their responses, make multiple-choice selections, or give no overt responses at all. There was no apparent difference in student learning if the sequence was presented by a machine, a programmed textbook, or a lecturer. It seemed that the sequence of items alone was important. However, the importance of the careful ordering of items became suspect when it was discovered that a student, who failed to read the introductory instructions of a programmed textbook, read down the page instead of from page to page so that the sequence of items he saw were numbered 1, 40, 79, 118, 157, 2, 41, 80, 119, 158, 3, 42, and so on. This student still managed to get a high score on the criterion test.

This report deals with an experiment designed to determine whether the presentation of a proper sequential ordering of related subject items does affect the terminal performance of a student differently than does the presentation of a random ordering of the same subject items. Stated as a hypothesis: The mean performance in a criterion test of students who have studied a proper sequential ordering of related subject items will be equal to the mean performance on the same criterion test by students who have studied a random ordering of the subject items. The

hypothesis is based on the use of subject items which are related, with one item normally depending on a preceding item, and on the students' terminal performance, rather than their performance on intermediate items. A variable which could affect the hypothesis is the number of items used in one learning session. It is obvious that if the program consisted of only three randomly ordered items, many students could memorize them, mentally unscramble or reorder them, and perform adequately on a terminal test. If the program consisted of 200 items, the problem of mentally storing and unscrambling them should be much more difficult. In this first experiment, the number-of-items variable was not explored. Only enough items to make up what would normally be a one-hour learning session (71 items, in this case) were used.

Shortly before this experiment was conducted, the work of Gavurin and Donahue[1] on logical sequence and random sequence was brought to the author's attention. Gavurin and Donahue used a program of 29 items, in a logical sequence for one group of subjects and in a randomized sequence for a second group. The latter sequence was divided into three blocks of 10, 10, and 9 items, with randomization occurring only within each block. Subjects in the second group, who presumably were not matched for verbal ability or prior knowledge of the material, were required to repeat all missed items within a block before proceeding to the next block. A criterion test was not administered until one month after the learning session. Gavurin and Donahue found that subjects who studied the random sequence made significantly more errors than those who studied the logical sequence. However, after one month there was no significant difference in the amount of retention of the material between the two groups.

It was anticipated that the current experiment would shed some light on the sequencing variable by (a) scrambling larger blocks of items, (b) choosing subject matter which had a minimum of "word" responses that may not require logical sequencing, (c) accounting for prior ability of subjects, (d) eliminating the repetition of missed items, which may tend to exaggerate the error score, and (e) eliminating the leveling effect

of time on long-term retention by administering the criterion test immediately after the learning session.

SUBJECTS

A group of 36 freshman psychology students were classified into upper, middle, and lower thirds according to their prior mathematical ability as indicated by quantitative scores on the American Council on Education (ACE) college entrance board examinations. Within each third, students were randomly assigned to each sequencing method. No pre-test was administered because previous studies with the program used indicate that lower division college students have little prior knowledge of the subject matter, and that the presence of such prior knowledge does not correlate with terminal performance after studying the programmed items.

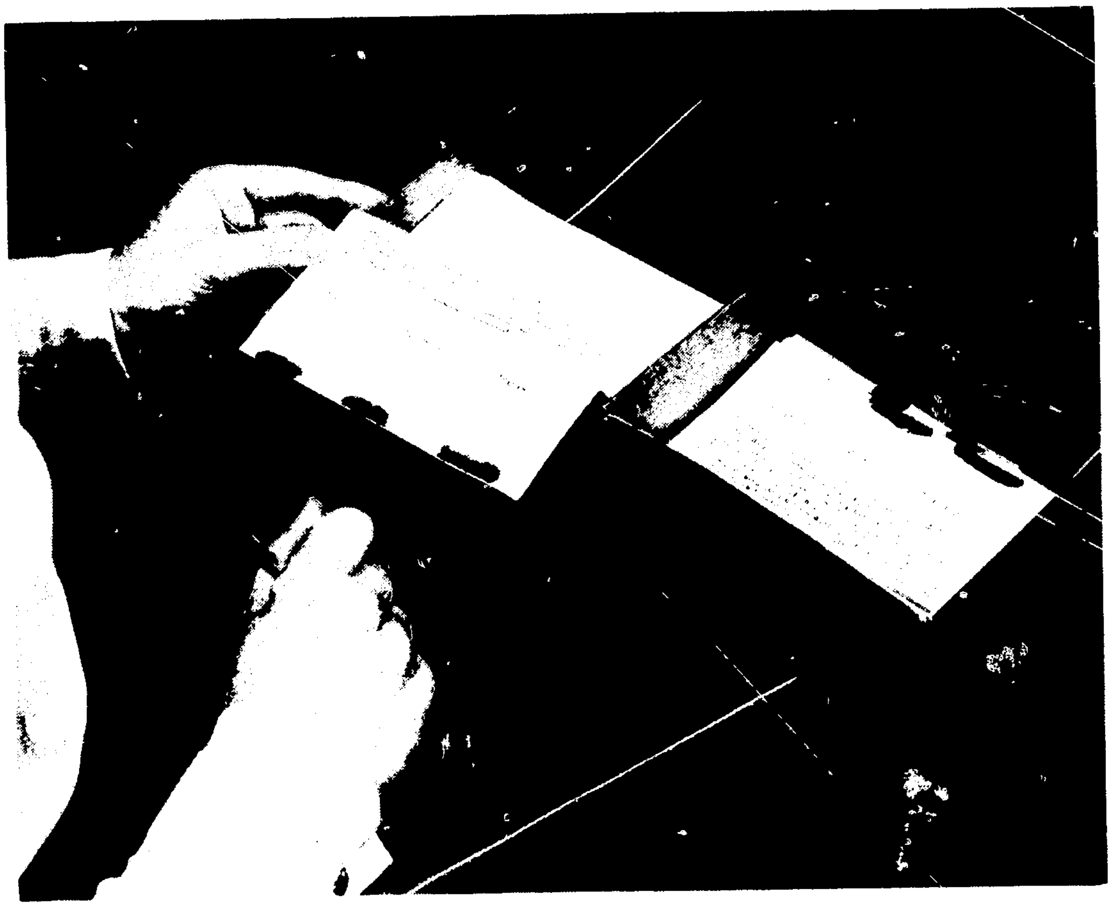
PROGRAM MATERIAL

The learning items consisted of 71 frames taken from the program on elementary probability developed over the past two years by members of the Teaching Systems Research Project at the Department of Engineering, University of California, Los Angeles. The concepts covered include relationship between information and degree of certainty, deterministic vs. probabilistic problems, probability ratio, additive law of probability, multiplicative law of probability, sampling with and without replacement, and mutually exclusive and independent events.

Each frame, printed on a 4- by 6-inch card, consisted of a learning item followed by a statement requiring multiple-choice completion. (See Figures 1 and 2.) The student had to remove a patch of opaque rubber cement (to which powdered graphite had been added) below one of the possible answers, thereby recording his choice as well as uncovering the correct response.

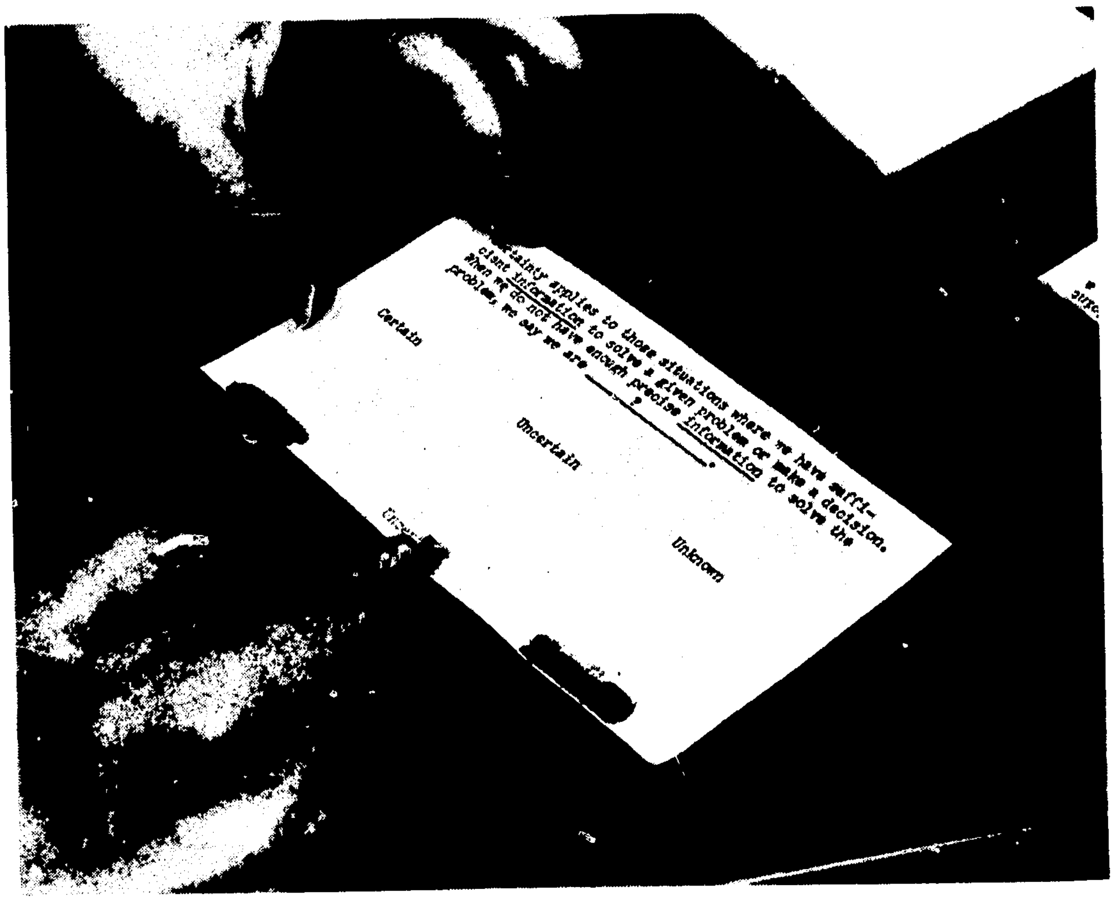
PROCEDURE

Students were gathered in a classroom and given instruction sheets and boxes containing the learning items. Half the students received boxes with an ordered sequence of items, and the other half received boxes with



THE PROGRAM CONSISTS OF A SEQUENCE OF 71 FRAMES (4"x 6" CARDS) ARRANGED IN A BOX. EACH ITEM REQUIRES A MULTIPLE-CHOICE COMPLETION.

FIGURE 1



THE STUDENT REMOVES THE MASKING MATERIAL BELOW THE ANSWER HE CHOOSES, UNCOVERING THE CORRECT ANSWER

FIGURE 2

a scrambled sequence of items. Immediately on completing the program, each student was given a subjective questionnaire and a criterion test. Times for completing the learning session and the criterion test were recorded. The boxes of cards were subsequently examined to find the number of errors made during the learning session.

STATISTICAL TREATMENT

Chi-square tests of normality of distributions were made for all variables and Bartlett's test for homogeneity of variances was made for all pertinent variances. In no case were the assumptions of normality or homogeneity of variances rejected, though it was recognized that for the sample sizes involved these tests were not powerful. Also t-tests were made to ascertain that the three mathematical aptitude strata were significantly different from one another and that, within each stratum, the groups were not significantly different from one another.

Analyses of variance were then performed on the following data: time required for learning, error score during learning, time required for criterion test, and criterion test scores. The two variables in each of these analyses of variance were the method of sequencing items and the students' mathematical aptitude.

Since programmed instruction is designed to bring most students up to a high level of performance on criterion items, it was expected that the distribution of criterion test scores would be skewed towards the high end (negatively skewed). Though this skewing was not large enough to negate the normality assumptions (for the limited size of the sample), non-parametric tests were also used on the criterion test scores. In all cases, the non-parametric test results were consistent with the analyses of variance results.

RESULTS

The row and column means and standard deviations for the variables are listed in Table I. The F ratios, degrees of freedom, whether the F ratio is significant at the $\alpha = .05$ level, and the level of α at which the F ratio becomes significant (for those who might properly protest against an arbitrary choice of α) are listed for the various hypotheses in Table II.

The sequence of items had no significant effect (at the $\alpha = .05$ level) on the dependent variables, nor was there any significant effect on the interaction between the sequence of items and prior mathematical aptitude.

However, prior mathematical aptitude did have a significant effect on the error scores and criterion test scores.

Though not significant, it is noted that the mean criterion test score of the students using the scrambled sequence is higher than that of the students using the ordered sequence.

CONCLUSIONS

Considerable importance had been attached to the careful sequencing of auto-instructional items by most program writers;[2] and it was thought that the student mentioned in the introduction, who, in an earlier experiment, had followed an improper sequence and still scored high on the criterion test, must have been unusually gifted. The results of this small-scale experiment, however, seem to indicate that college level students may not require the careful sequencing of auto-instructional items as had previously been supposed. A clue to the possible reason comes from a conversation with one of the students immediately after the conclusion of the experiment.

Student:	What kind of program was that?
Experimenter:	Why do you ask?
Student:	I was finding all kinds of things I didn't know and couldn't answer and was getting curious about what was going on.
Experimenter:	What did you do?
Student:	Well, I kept looking for the information for the items I couldn't answer, and when I found them later on I felt very glad.

TABLE I

MEANS AND S.D,

	Time Required for Learning (min)		Error Score During Learning		Time Required for Criterion Test (min)		Criterion Test Scores	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
<u>Sequence</u>								
Scrambled	45.0	7.9	10.2	4.7	15.6	3.5	7.3	2.4
Ordered	46.5	8.7	9.3	4.6	15.9	5.5	6.3	2.3
<u>Math. Aptitude</u>								
Upper Third	45.75	7.7	7.3	3.9	14.7	3.0	8.0	2.0
Middle Third	44.5	9.8	9.5	3.1	16.1	4.7	7.5	2.1
Lower Third	47.3	7.5	12.4	4.2	16.4	5.7	5.3	2.3

TABLE II

ANALYSES OF VARIANCE RESULTS

		DF		Significance	
	F ratio	v_1	v_2	At α = .05	At α approx.
Time Required for Learning					
Sequence	0.30	1	30	NS	0.65
Aptitudes	0.36	2	30	NS	0.70
Interactions	2.42	2	30	NS	0.10
Error Score During Learning					
Sequence	0.64	1	30	NS	0.55
Aptitudes	4.9	2	30	S	0.02
Interactions	1.65	2	30	NS	0.20
Time Required for Criterion Test					
Sequence	0.04	1	30	NS	0.95
Aptitudes	0.46	2	30	NS	0.70
Interactions	0.11	2	30	NS	0.90
Criterion Test Scores					
Sequence	2.32	1	30	NS	0.15
Aptitudes	5.11	2	30	S	0.02
Interactions	0.64	2	30	NS	0.55

Possibly, a closely ordered sequence of items, in which the information for completing a given item has been supplied in immediately preceding items, can be followed easily and without much more than short-time recall attention. Presenting items out of sequence possibly introduced a task-oriented anxiety which was subsequently relieved in a moment of revelation when a missing clue was discovered. That the students using the scrambled sequence of items were possibly more alert is indicated by the fact that the five comments concerning typographical errors in the program were made by students in this group.

It is difficult to generalize from an experiment using a limited number of students studying a narrowly defined subject area in an ad hoc situation. It would be interesting to examine the scrambled versus ordered sequence question with students of various age levels, with programs of different length and in different subject areas, and with retention tests made at spaced intervals of time.

The Teaching Systems Research Project has scheduled an experiment for September, 1961, in which approximately 200 college freshman engineering students will be exposed to various branching procedures, a linear sequence of items, and a scrambled sequence of items. There will be approximately 200 items in the linear and scrambled sequences.

REFERENCES

1. E.I. Gavurin, and V.M. Donahue, "Logical Sequence and Random Sequence," Automated Teaching Bulletin, Vol. 1, No. 4, Spring, 1961.

2. A. Roe, and H. Moon, "Analysis of Course Content for Individual Learning," Automated Teaching Bulletin, Vol. 1, No. 3, Summer, 1960.

3. A. Roe, et al., Automated Teaching Methods Using Linear Programs, Report No. 60-105. Department of Engineering, University of California, Los Angeles, December, 1960.